GRADE 12 DIPLOMA EXAMINATION

Physics 30

January 1991

Alberta
EDUCATION

GRADE 12 DIPLOMA EXAMINATION
PHYSICS 30

DESCRIPTION

Time: 2½ hours

Total possible marks: 70

This is a **closed-book** examination consisting of **two** parts:

PART A has 49 multiple-choice questions each with a value of one mark.

PART B has four written-response questions for a total of 21 marks.

A physics data booklet is provided for your reference.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work. **No marks** will be given for work done on the tear-out pages.

GENERAL INSTRUCTIONS

Fill in the information required on the answer sheet and the examination booklet as directed by the examiner.

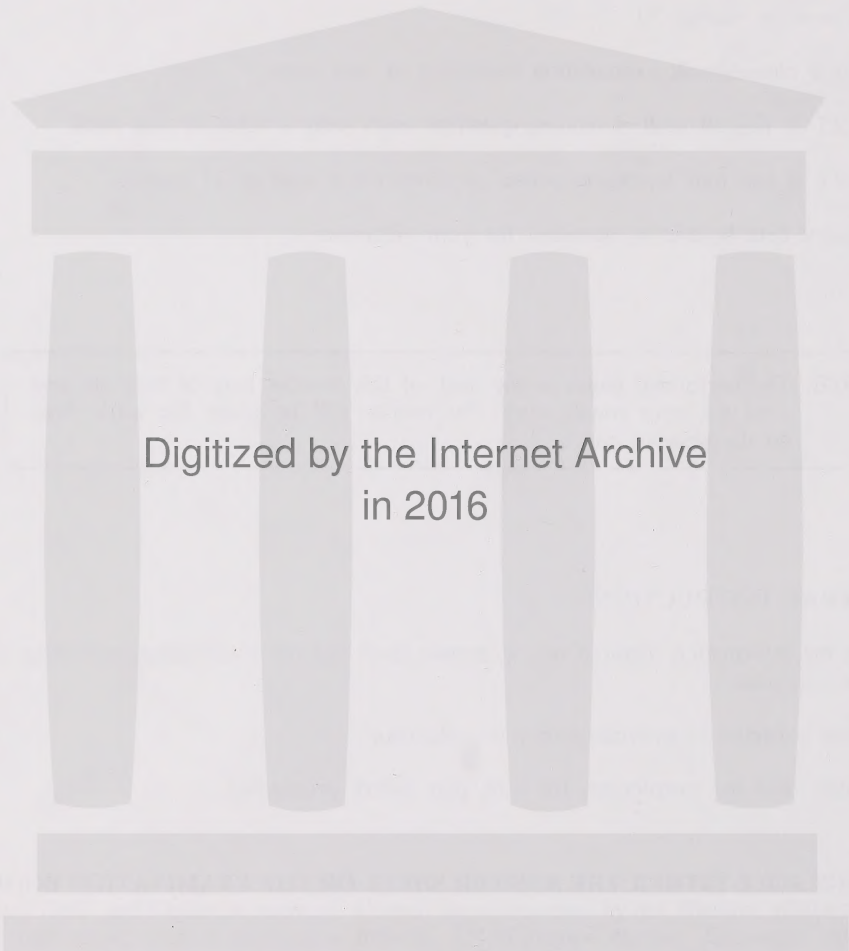
You are expected to provide your own calculator.

Carefully read the instructions for each part before proceeding.

DO NOT FOLD EITHER THE ANSWER SHEET OR THE EXAMINATION BOOKLET.

The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.

JANUARY 1991



PART A

INSTRUCTIONS

In this part of the examination, there are 49 multiple-choice questions each with a value of one mark. All numbers used in the questions are to be considered as the result of a measurement.

Read each question carefully and decide which of the choices **best** completes the statement or answers the question. Locate that question number on the separate answer sheet provided and fill in the space that corresponds to your choice. **Use an HB pencil only**.

Example

This diploma examination is for the subject of

A. Biology
B. Physics
C. Chemistry
D. Mathematics

Answer Sheet

A	B	C	D
①	●	③	④

If you wish to change an answer, erase your first mark completely.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work. **No marks** will be given for work done on the tear-out pages.

DO NOT TURN THE PAGE TO START THE EXAMINATION UNTIL TOLD TO DO SO BY THE PRESIDING EXAMINER.

1. Polarization of light can most easily be explained by assuming that light is a

   A. transverse wave
   B. longitudinal wave
   C. stream of photons
   D. stream of particles with different speeds

2. Galileo was unsuccessful in his attempt to measure the speed of light because

   A. he could not produce a suitable vacuum
   B. he did not have lenses to produce a narrow parallel light beam
   C. his reaction time was greater than the travel time of his light beam
   D. the speed of light is so high that it cannot be measured without using electronic equipment

3. Light travelling in medium X strikes a surface and refracts into air. The angle of incidence is 22° and the angle of refraction is 53°. The speed of light in medium X is

   A. 6.4×10^8 m/s
   B. 2.6×10^8 m/s
   C. 1.4×10^8 m/s
   D. 1.2×10^8 m/s

4. Light passes through a double slit and produces images on a screen that is 20.0 m away. If the second-order bright image is formed at a distance of 0.720 m from the central maximum, how far from the central maximum will the third-order bright image be formed?

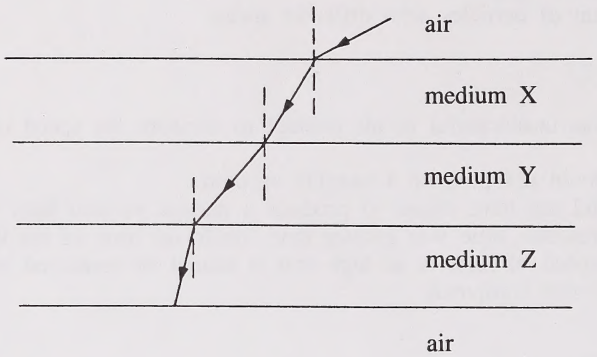
   A. 2.16 m
   B. 1.08 m
   C. 0.480 m
   D. 0.240 m

5. An object appears red when it is illuminated by white light. What color will the object probably appear to be when it is illuminated by pure green light?

   A. Red
   B. Black
   C. Green
   D. Yellow

Use the following information to answer question 6.

A ray of light travels through three transparent media.



This diagram **is** drawn to scale.

6. The relationship between the indices of refraction of the three media X, Y, and Z can be represented by the inequalities

A. $n_y < n_x < n_z$

B. $n_y < n_z < n_x$

C. $n_y > n_x < n_z$

D. $n_y > n_z < n_x$

---

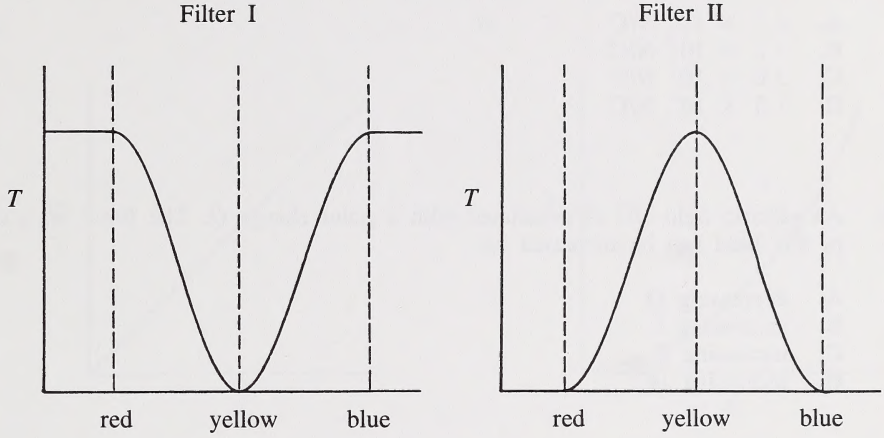
7. A factor that does **not** affect the distance between bright lines in a double-slit experiment is the

A. slit separation
B. width of the slits
C. distance to the screen
D. wavelength of the light

8. White light passes through a pair of polarizing filters and is incident on a light meter. If the second filter is rotated by 180°, the intensity of the light shining on the light meter will be

A. zero
B. halved
C. doubled
D. unchanged

Use the following information to answer question 9.



Each graph illustrates the transmission T of light as a function of color for a particular filter.

9. Which colors of light can pass through both filters?

A. All
B. Red and blue only
C. Orange and green only
D. Red, yellow, and blue only

---

10. The electric force between two point charges varies

A. inversely as the product of the charges and directly as the distance between them

B. inversely as the product of the charges and inversely as the distance between them

C. directly as the product of the charges and directly as the square of the distance between them

D. directly as the product of the charges and inversely as the square of the distance between them

11. The electric field between two parallel plates that are 0.20 m apart and have a potential difference of 6.0×10^2 V is

A. 3.0×10^1 N/C
B. 1.2×10^2 N/C
C. 3.0×10^3 N/C
D. 1.5×10^4 N/C

12. An electric field $|\vec{E}|$ is associated with a point charge Q. The force on a charge q in this field can be increased by

A. decreasing Q
B. decreasing k
C. increasing R
D. increasing $|\vec{E}|$

13. The magnitude of the electric field strength at a point within a field is defined as the

A. charge on a unit mass at that point

B. force per unit charge acting on a small test charge at that point

C. work done in raising the potential difference at that point by one volt

D. force exerted on one metre of a wire that carries a current of one ampere and is perpendicular to the field at that point

14. If a 3.0×10^{-6} C positive charge with a mass of 4.0×10^{-3} kg is released 6.0 cm from a fixed 2.0×10^{-6} C positive charge, the magnitude of its initial acceleration is

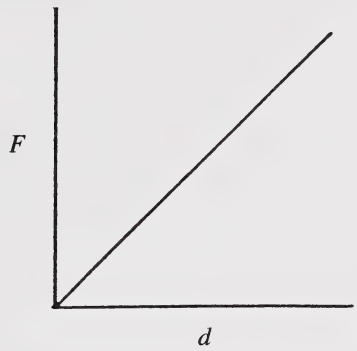
A. 1.5×10^1 m/s^2
B. 2.3×10^2 m/s^2
C. 3.7×10^3 m/s^2
D. 1.3×10^9 m/s^2

15. The most appropriate equation for calculating the voltage V across the filament of a light bulb is

A. $V = IR$
B. $V = |\vec{E}|d$
C. $Vq = \Delta E$
D. $Vq = hf - W$

16. The graph connecting force F and distance d that represents Newton's universal gravitation law is

A.



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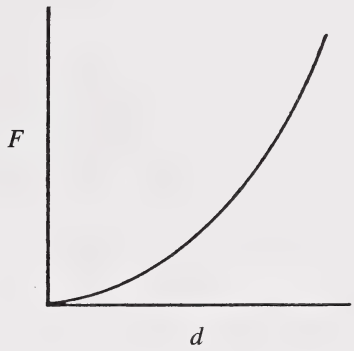

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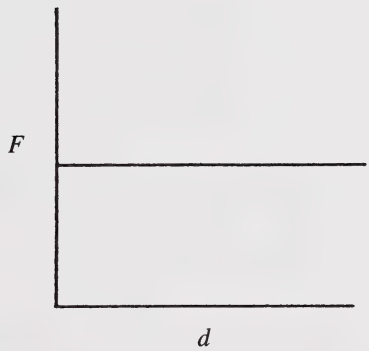
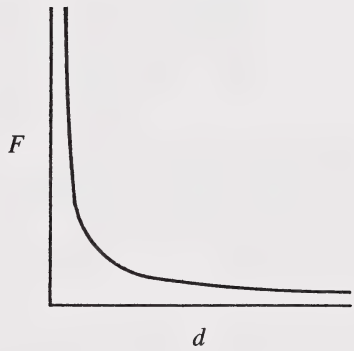


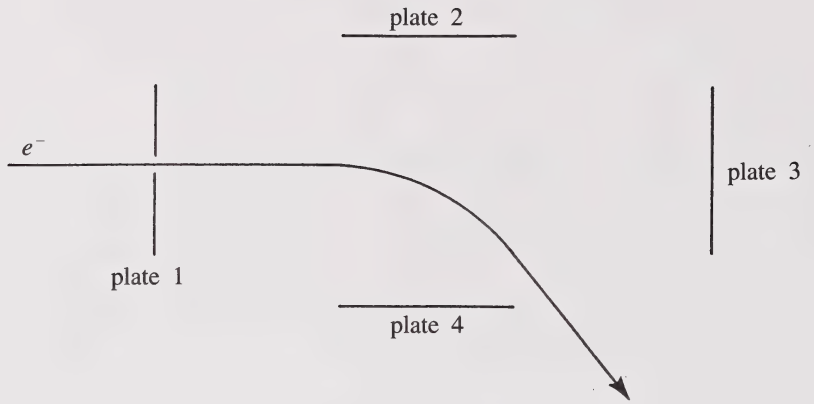
D.



17. The potential difference between the anode and the cathode of a vacuum tube is 2.0×10^2 V. Free electrons originate at the cathode with negligible speed and move to the anode. The speed with which the electrons arrive at the anode is

A. 8.4×10^6 m/s
B. 4.2×10^6 m/s
C. 2.0×10^5 m/s
D. 9.8×10^4 m/s

Use the following information to answer question 18.



A beam of electrons moves horizontally to the right and enters the region between parallel plates 2 and 4, where the beam is deflected by an electric field as shown.

18. The direction of the electric field that causes this vertical deflection is from

A. plate 4 to plate 2
B. plate 2 to plate 4
C. plate 3 to plate 1
D. plate 1 to plate 3

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19. A 12 V storage battery has a charge of 3.6×10^5 C. How long can this battery operate a motor of resistance 0.60 Ω before the charge is exhausted?

A. 7.2×10^6 s
B. 6.0×10^5 s
C. 2.2×10^5 s
D. 1.8×10^4 s

Use the following information to answer questions 20 and 21.

An alpha particle, of mass m and charge q, undergoing an acceleration because of an external potential difference V has a physical quantity S associated with it. The formula for S is

$$S = \sqrt{2qVm}$$

20. When the potential difference is 7.62×10^4 V, the numerical value of S in SI units is

A. 3.2×10^{-40}
B. 1.8×10^{-20}
C. 4.5×10^{-11}
D. 4.4×10^{-7}

21. The appropriate SI unit for S is equivalent to the SI unit for

A. force
B. energy
C. momentum
D. magnetic field intensity

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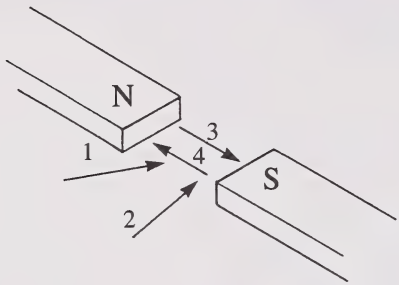
22. An electron experiences a force F as it moves across a magnetic field. When its speed is doubled and the magnetic field is tripled, the force on the electron is

A. $F/6$
B. $2F/3$
C. $3F/2$
D. $6F$

23. If a proton travelling at 4.0×10^4 m/s enters perpendicularly into a magnetic field with a strength of 5.0×10^{-2} T, the radius of curvature of its path will be

A. 1.2×10^{-6} m
B. 8.4×10^{-3} m
C. 14 m
D. 120 m

Use the following information to answer question 24.



This diagram shows the directions of motion of four charged particles in a magnetic field.

24. The magnetic field will deflect the particles labelled

A. 1 and 2
B. 1 and 3
C. 2 and 4
D. 4 and 3

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25. The observation of an electric field in a conductor when the conductor moves at right angles through a magnetic field is an example of

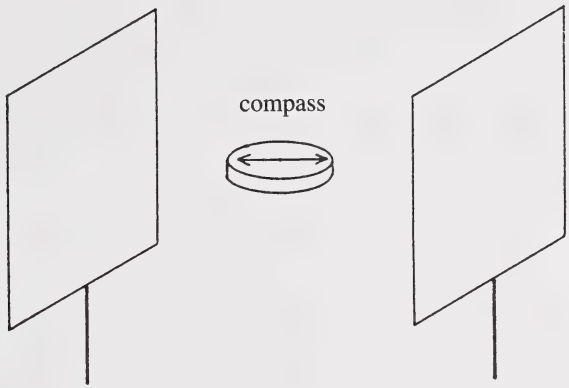
A. Ohm's law
B. the determination of q/m
C. electromagnetic induction
D. the definition of an ampere

26. When an electromagnetic wave passes from a medium with a low index of refraction to one with a high index of refraction, it will

A. increase in speed
B. decrease in speed
C. increase in frequency
D. decrease in frequency

Use the following information to answer question 27.

A compass is placed between two uncharged plates as shown. One plate receives a charge of $+Q$, while the other plate receives a charge of $-Q$. The two plates are then discharged.



The compass is observed during the following time intervals:

I. when the plates are being charged
II. when the plates are maintained at full charge
III. when the plates are being discharged

27. The compass needle will be deflected by the plates during time interval(s)

A. II only
B. I and II only
C. I and III only
D. I, II, and III

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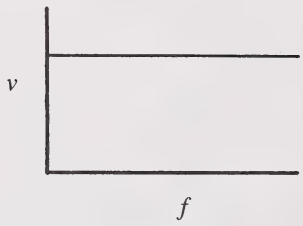
28. Telecommunication towers cannot be much more than 80 km apart because microwaves

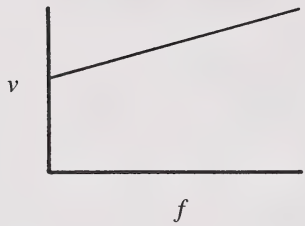
A. are refracted away from the Earth
B. are diffracted by hills and buildings
C. would otherwise be blocked by the curvature of the Earth
D. interfere destructively with other forms of electromagnetic radiation

29. The graph that relates velocity in a vacuum to frequency for electromagnetic radiation is

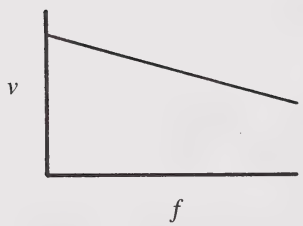
A.



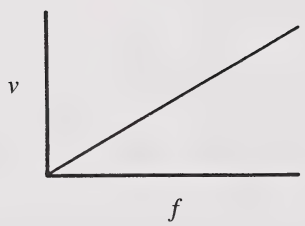
B.



C.



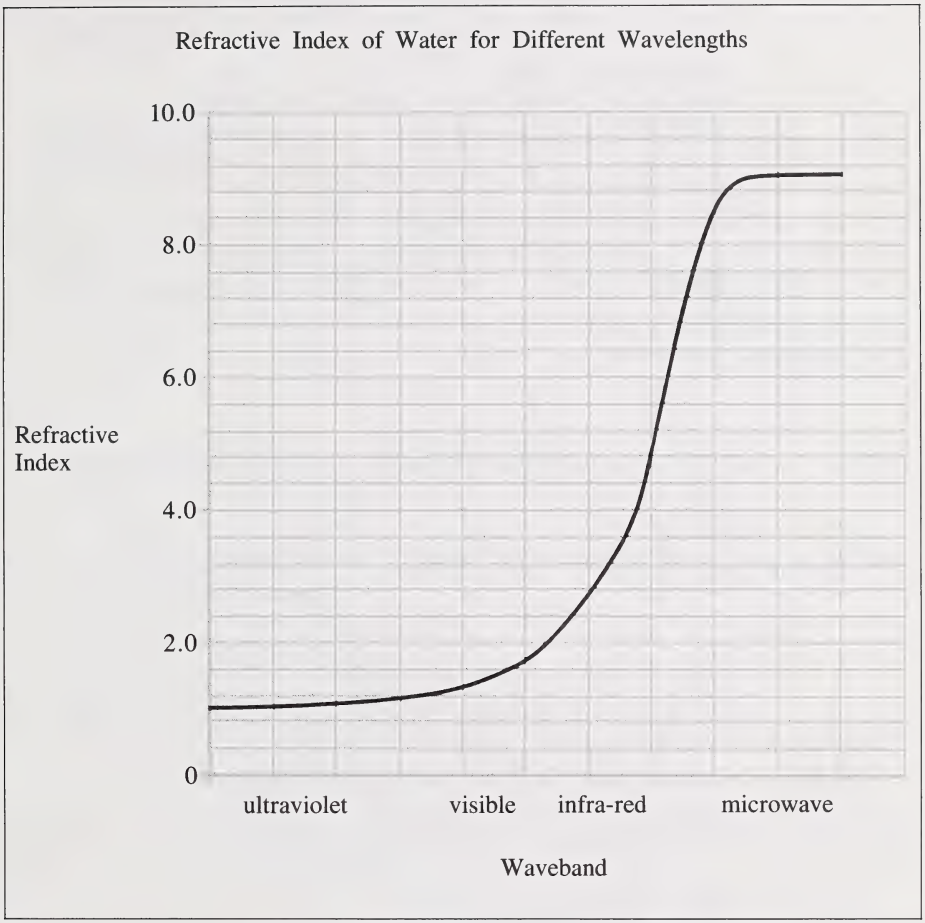
D.



30. Light of wavelength 7.0×10^{-7} m travels a distance equal to its own wavelength. The time taken to accomplish this is

A. 2.3×10^{-15} s
B. 4.8×10^{-3} s
C. 2.1×10^{2} s
D. 4.3×10^{14} s

Use the following information to answer question 31.



31. A short-wavelength ultraviolet signal and a radar signal are transmitted through water. Compared with the short-wavelength ultraviolet signal, the speed of the radar signal is

A. 8 times faster
B. 8 times slower
C. 9 times faster
D. 9 times slower

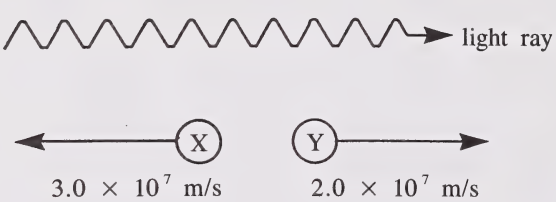
Use the following information to answer question 32.

Radiation Types	Radiation Sources
1. monochromatic light	I. lasers
2. X-ray	II. unstable nuclei
3. gamma	III. decelerating electrons
4. microwave	IV. electronic oscillators

32. The radiation sources that match radiation types 1, 2, 3, and 4 respectively are

A. II, I, III, and IV
B. II, I, IV, and III
C. I, II, III, and IV
D. I, III, II, and IV

Use the following information to answer question 33.



Two moving observers, X and Y, measure the speed of a light ray.

33. The speed of the light ray, as measured by X and Y respectively, is

A. 3.3×10^8 m/s and 2.8×10^8 m/s
B. 3.0×10^8 m/s and 3.0×10^8 m/s
C. 2.7×10^8 m/s and 3.2×10^8 m/s
D. 1.0×10^8 m/s and 1.5×10^8 m/s

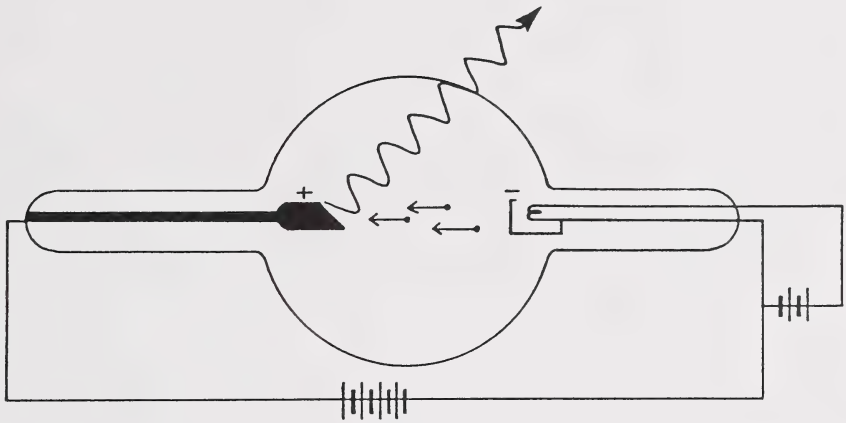
---

34. Volta's electric cell proved to be more advantageous to the study of electrochemistry than the Leyden jar did because it provided

A. a steady current
B. a higher voltage
C. an alternating current
D. a shorter discharge time

Use the following information to answer question 35.

An X-ray Tube



35. Which of the following would **not** have an effect on the maximum frequency of the X-ray radiation produced?

A. The speed of the electrons
B. The kinetic energy of the electrons
C. The distance between the electrodes
D. The potential difference across the electrodes

---

36. Given the equation $C + O_2 \longrightarrow CO_2$, the mass of oxygen that reacts with 5.0 g of carbon to form carbon dioxide is

A. 18 g
B. 13 g
C. 10 g
D. 6.7 g

37. A 20.0 A current flows for 1.00 h through a molten compound that contains an element with a valence of 2. If 23.7 g of the element are deposited at an electrode, the element is most likely to be

A. tellurium
B. hydrogen
C. sulphur
D. copper

38. A positively charged oil drop weighing 1.0×10^{-13} N is suspended between oppositely charged horizontal plates. If the plates are 1.0 cm apart and are maintained at a potential difference of 2.0×10^{2} V, the charge on the oil drop is

A. 5.0×10^{-18} C
B. 5.0×10^{-16} C
C. 2.0×10^{-11} C
D. 2.0×10^{-9} C

39. An electron passes without deflection through crossed electric and magnetic fields of strengths 3.80×10^{6} N/C and 4.90×10^{-2} T respectively. If the electric field is removed, the electron will orbit in the magnetic field with a radius of curvature of

A. 7.76×10^{7} m
B. 1.11×10^{2} m
C. 9.01×10^{-3} m
D. 4.42×10^{-4} m

40. Electrons are accelerated through a potential difference of 28 kV and are directed toward a metal plate. When the electrons strike the metal plate, a significant part of their energy will be emitted in the form of

A. metal ions
B. X-ray radiation
C. gamma radiation
D. microwave radiation

41. In his atomic model, Bohr assumed that electrons

A. always remain in the same orbit
B. may exist only in certain orbits
C. lose energy while accelerating in circular paths
D. gain energy while accelerating in circular paths

42. The observation of large scattering angles in Rutherford's experiment led to the inference that

A. electrons and protons are oppositely charged
B. nuclei of atoms have relatively large volumes
C. electrons have a large volume but a small mass
D. the mass of an atom is concentrated at its centre

Use the following information to answer question 43.

Initial energy of bombarding particles:

I. 1.1 eV
II. 6.3 eV
III. 10.9 eV
IV. 11.6 eV

Quanta of energy that are allowed to be absorbed by target atoms:

5.2 eV or 9.8 eV or 12.7 eV

43. If the bombarding particles were electrons, for which initial case(s) could the scattered electrons have 1.1 eV of kinetic energy?

A. I only
B. I and IV
C. I and II only
D. I, II, and III

---

44. One line in the emission spectrum of hydrogen corresponds to a wavelength of 4.85×10^{-7} m. This line is produced by an electron that drops to level $n_f = 2$ from level

A. $n_i = 1$
B. $n_i = 3$
C. $n_i = 4$
D. $n_i = 5$

45. An object with a rest mass of 3.43×10^{-26} kg has a relativistic mass of 7.81×10^{-26} kg. Its speed is

A. 2.70×10^{8} m/s
B. 2.42×10^{8} m/s
C. 2.25×10^{8} m/s
D. 1.74×10^{8} m/s

46. The Compton effect indicates that photons have

A. frequency
B. momentum
C. velocity
D. mass

47. The observation of diffraction of electrons incident on crystals indicates that

A. electrons are scattered by photons
B. the momentum of electrons is conserved
C. moving electrons exhibit wave properties
D. the energy of moving electrons is quantized

48. One of the foundations of quantum mechanics is that simultaneous measurement to arbitrary accuracy of momentum and position is impossible. This idea is credited to

A. Bohr
B. Compton
C. de Broglie
D. Heisenberg

Use the following information to answer question 49.

I. A car travelling at 100 km/h

II. A proton travelling at 200 m/s

III. A planet circling the sun every 3.7 years

IV. An electron travelling to the anode in a cathode ray tube

49. The de Broglie wavelength is measurable, using present technology, for

A. I and II
B. I and III
C. II and IV
D. III and IV

YOU HAVE NOW COMPLETED PART A. PROCEED DIRECTLY TO PART B.

PART B

INSTRUCTIONS

In this part of the examination, there are four written-response questions for a total of 21 marks. All numbers used in the questions are to be considered as the result of a measurement.

Write your solutions in the examination booklet as neatly as possible.

Your solutions **must show all** pertinent explanations, calculations, and formulas. Full marks will be assigned **only** to those solutions that **show** all pertinent explanations, calculations, and formulas.

All numerical answers must be given correct to the appropriate number of significant digits.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work. **No marks** will be given for work done on the tear-out pages.

START PART B IMMEDIATELY.

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(4 marks)

1. In a photoelectric experiment, a student illuminated a cesium photocell (W = 1.92 eV) and calculated the maximum kinetic energy of the ejected photoelectrons. As a first step, the student calibrated the wavelength of the incident light by passing it through a double slit of spacing 3.51×10^{-4} m. In the calibration, the student measured the bright-line spacing to be 2.82×10^{-3} m on a screen 2.00 m from the double slit. Calculate the maximum kinetic energy of the photoelectrons. Express your answer to two significant digits.

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2. Identical metal spheres A and B have an equal charge Z and repel each other with a force of 4.0×10^{-6} N at a distance of x cm. A third metal sphere C, identical but neutral, is allowed to touch A first, B next, and then is moved far away. Calculate the new force of repulsion between metal spheres A and B.

(4 marks)

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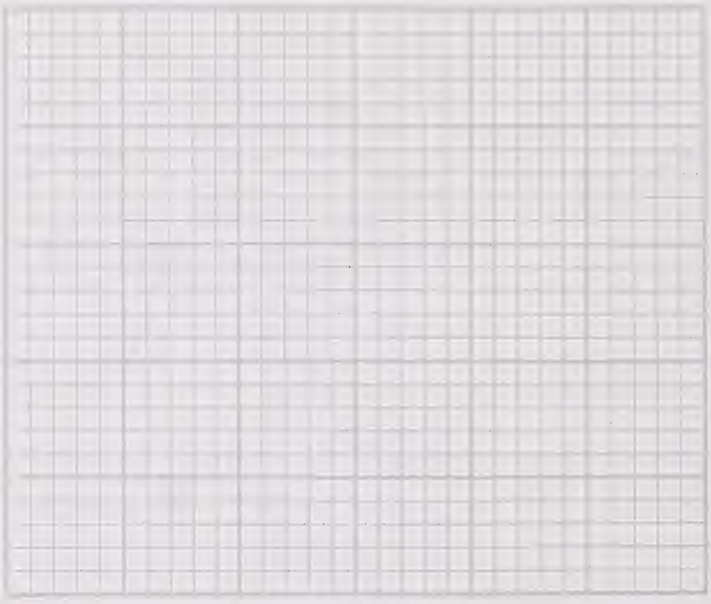
3. Independent measurements were made of the momentum p and of the frequency f of X-rays.

The results are summarized in the table:

p (10^{-23} kg•m/s)	f (10^{19} Hz)
2.5	1.3
8.0	3.9
13.0	5.4
17.0	8.1
20.0	8.8
22.0	11.2

(2 marks)

a. From the data in the table, plot a graph of momentum as a function of frequency, placing frequency on the horizontal axis.



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b. Use the slope of the graph or some other suitable averaging procedure to determine the **best** estimate of Planck's constant h. **(3 marks)**

c. Find the percentage error in your estimate of Planck's constant. **(1 mark)**

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Use the following information to answer question 4.

Buildings A and B are each 25 stories tall. Between them are a large shopping mall and other smaller buildings. The distance between buildings A and B was measured, using a laser and other electronic instruments, three times per day. The measurements are given in the table:

Distance (m)	Time of day
15 165.67	7:00 a.m.
15 165.35	11:00 a.m.
15 165.12	3:00 p.m.
15 165.53	7:00 a.m.
15 165.22	11:00 a.m.
15 165.18	3:00 p.m.
15 165.58	7:00 a.m.
15 165.31	11:00 a.m.
15 165.20	3:00 p.m.

The laser and other electronic instruments operate on standard 115 V electrical outlets. The laser and auxiliary timing equipment can measure all distances greater than 10 metres to seven significant digits.

(1 mark)

4. a. What is the average measured distance between buildings A and B?

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b. Listed below are three hypotheses to account for variation in the measured distance between buildings A and B. Choose **one** of the hypotheses and design a **practical** experiment to test its validity. A sketch may be helpful. Your experimental design must **control** or **exclude** possible effects suggested by the other two hypotheses. You must also **specifically** state the observations and/or measurements you use in your experiment to evaluate the hypothesis you have chosen.

(6 marks)

Hypotheses

(choose **one**)

I. The voltage applied to the laser changes with time, thus affecting the frequency emitted by the laser and, therefore, the measured distance.

II. The refractive index of air depends on temperature.

III. The buildings sway.

Please note that in the practical experiment you design, you do not have to duplicate the distance measurements given on page 22. You may select any suitable equipment in order to test the validity of the hypothesis you choose.

[More space is available on page 24 overleaf.]

Continued

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YOU HAVE NOW COMPLETED THE EXAMINATION. IF YOU HAVE TIME, YOU MAY WISH TO GO BACK AND CHECK YOUR ANSWERS.

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PHYSICS 30

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